THE ARCHITECTURAL RELEVANCE OF CYBERNETICS

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t is easy to argue that cybernetics is relevant to rchitecture in the same way that it is relevant o a host of other professions; medicine, ngineering or law. PERT programming, for xample, is unequivocally a 'cybernetic' echnique and it is commonly employed in onstruction scheduling. Computer assisted esign is a 'cybernetic' method and there are everal instances of its application to architecture, or example, the WSCC's planning scheme in hich the designer uses a graphic display to epresent the disposition of structural modules n a grid and in which the computer summarizes ne cost effort consequences of a proposed yout). Of these cases the first (PERT rogramming) is a valuable but quite trivial pplication of cybernetics; the second is likely o have a far-reaching influence upon rchitectural design. But neither of them emonstrate more than a superficial bond between ybernetics and architecture. If we leave the natter at this level, then architects dive into a ybernetic bag of tricks and draw out those hich seem to be appropriate. That is a perfectly easonable thing to do, of course. But cybernetics nd architecture really enjoy a much more ntimate relationship; they share a common hilosophy of architecture in the sense that tafford Beer has shown it to be the philosophy f operational research.

The argument rests upon the idea that rchitects are first and foremost system designers ho have been forced, over the last 100 years r so, to take an increasing interest in the rganizational (i.e. non-tangible) system roperties of development, communication and ontrol. Design problems were coped with as ney cropped up, but for some time it has been, vident that an underpinning and unifying theory required. Cybernetics is a discipline which lls the bill insofar as the abstract concepts of ybernetics can be interpreted in architectural erms (and, where appropriate, identified with al architectural systems), to form a *theory* rchitectural cybernetics, the cybernetic theory f architecture).[1]

Historical roots[2]

n or before the early 1800s 'pure' architecture kisted as an abstraction from the art of uilding. Its rules were essentially condensed atements of what could be observed by looking builders working on a site, and by looking buildings constructed during different periods nd in different places. Architects added a odicum of engineering practice and of historical aesthetic sensibility to their discipline and reated new structures with *stability* and *style*. n the whole, their structures were judged, ithin 'pure' architecture, according to these anons.

Even in those days, of course, architects ere asked to solve problems entailing the gulation and accommodation of human beings; ence, to design systems. But, in a sense, their rief was quite narrow. The problems could all e solved by the judicious application of pure rchitectural rules. The form of the artefact ouse, college or theatre) was largely determined y the quite rigid codes of architecture lictating, for example, its acceptable whole part lationships) and by the conventions of society r the individual practitioner. Speaking chnically, there were well accepted communica-on media for conveying instructions, directives nd ideas (style manuals and so on). Further, here was a *metalanguage* for talking about these structions, directives and ideas, for comparing them, criticizing them and evaluating them (as in statements of stability or style). Indeed, when interpreted, the body of metalinguistic statements formed the theory of pure architecture. Consequently, architects did not need to see themselves as systems designers, even though they designed systems, and the evidence suggests that they did not do so.[3] Instead the professional image was that of a sophisticated house, college or theatre builder.

In the course of the Victorian era new techniques were developed too rapidly to be assimilated into pure architecture and new problems were posed and could no longer be solved by applying the rules of pure architecture, for example, make a 'railway station' or make a 'great exhibition'. The solution to such (in those days) outlandish problems clearly depends upon seeing the required building as a part of the ecosystem of a human society. Of course the problems were solved and the novel techniques were mustered for this purpose (Temple Meads, the Tropical House at Kew, the Crystal Palace). To my own taste the solutions are exceptionally beautiful.[4] Nevertheless, they are individual and idiosyncratic solutions because, in the new context, there was no way of carrying on a general and critical discussion. Let us be clear about this point. There obviously *was* a great deal of discussion over I. K. Brunel, D. Burton and J. Paxton's use of glass and ironwork; technical discussion and aesthetic discussion. But nobody seems to have appreciated the full significance of their structures in the context of the architectural potentialities of the age, i.e. as examples of *system* design. The reason is fairly obvious. Whereas the pure architecture of the early 1800s had a metalanguage, albeit a restrictive one which discouraged innovation, the new (augmented) architecture had not yet developed one. Another way of putting it is to say there was no theory of the new architecture.[5]

Architectural sub-theories

In place of a general theory there were sub-theories dealing with isolated facets of the field; for example, theories of materials, of symmetry, of human commitment and responsibility, of craftsmanship and the like. But (it is probably fair to say) these sub-theories developed more or less independently during the late 1800s.

Naturally enough, each sub-theory fostered a certain sort of building or a certain sort of socio-architectural dogma; for example, futurism. However, the point of immediate interest is that many of the sub-theories were system orientated; although they anticipated the invention of the word they were, in an embryonic sense, 'cybernetic' theories and the thinking behind them made a valuable contribution to the development of cybernetics as a formal science.

Architectural functionalism and mutualism

A structure exists chiefly to perform certain functions, for example, to shelter its occupants or to provide them with services. At this level, a 'functional' building is contrasted with a 'decorative' building; it is an austere structure, stripped of excrescences. But, the concept of functionalism can be usefully refined in an humanistic direction. The functions, after all, are performed *for* human beings or human societies. It follows that a building cannot be viewed simply in isolation. It is only meaningful as a human environment. It perpetually interacts with its inhabitants, on the one hand serving them and on the other hand controlling their behaviour. In other words structures make sense as parts of larger systems that include human components and the architect is primarily concerned with these larger systems; *they* (not just the bricks and mortar part) are what architects design. I shall dub this notion architectural 'mutualism' meaning mutualism between structures and men or societies.

One consequence of functionalism and mutualism is a shift of emphasis towards the *form* (rather than the material constitution) of structures; materials and methods come into prominence quite late in the design process. Another consequence is that architects are required to design *dynamic* rather than *static* entities. Clearly, the human part of the system is dynamic. But it is equally true (though less obvious) that the structural part must be imaged as continually regulating its human inhabitants.

Architectural holism

Once a rudimentary version of the functional/mutualistic hypothesis has been accepted, the integrity of any single system is questionable. Most human/structural systems rely upon other systems to which they are coupled via the human components. By hypothesis, there are organizational wholes which cannot be meaningfully dissected into parts.

Holism is of several types:

a A functionally interpreted building can only be usefully considered in the context of a city (notice that the city is also functionally interpreted and, as a result, is a dynamic entity).

b A (functionally interpreted) structure, either a building or an entire city, can only be meaningfully conceived in the context of its temporal extension, i.e. its growth and development.

c A (functionally interpreted) structure exists as part of an intention, i.e. as one product of a *plan*.

d If (assumed dogma) man should be aware of his natural surroundings, then buildings should be wedded to or arise from these surroundings (Wright's organic thesis).

It is a corollary of *a*, *b* and *c* that the structure of a city is not just the carapace of society. On the contrary, its structure acts as a symbolic control programme on a par with the ritual constraints which are known to regulate the behaviour of various tribes and which render this

[1] Very similar comments apply to engineering, since engineers, like architects, prescribe artefacts. Surely, also, some engineers make use of a cybernetic theory. But the requirement is not so ubiquitous in engineering; nor is the impact of cybernetics so great because a creditable body of engineering theory, a predictive and explanatory theory, existed long before the cybernetic concepts came along as daring innovations. Moreover, whilst all architects design systems that interact closely with human beings and societies, most engineers (there are obvious exceptions) are not forced to do so. Human interaction is a major source of difficulties which can only be overcome by cybernetic thinking.

[2] The choice of a historical origin is somewhat arbitrary and depends upon the author's emphasis. For example, Alexander, preoccupied with the logic of form, traces essentially cybernetic concepts back to Lodoli and Laugier. In the present article I am anxious to follow the pragmatic development of cybernetic ideas and to see them emerging in the history of modern architecture.

[3] There are two important sorts of exception:
(i) Architects of genius, with a breadth of vision that impels them to see things in a systemic and interdisciplinary fashion. They have existed over the years: Sir Christopher Wren and Sir John Soane, for example.
(ii) Men like John Nash, whose talents lay in conceiving an urban development as a functional and aesthetic whole. But, within the tenets of the early 1800s such men are probably 'organizers with a vision', rather than 'architects'.

[4] I have chosen these examples partly because they are well known in the textbooks but mainly because I am impressed by their systemic qualities and the way in which they convey their designer's purpose to the occupant. Two of them still exist. I just recall the Palace. Even in its tawdry reincarnation it was a remarkable structure. Since it was one of the first instances of a prefabricated building it also counts as a piece of system design at the engineering level.

[5] Lack of an adequate metalanguage was not the only factor. As Prof. Nicolaus Pevsner points out the engineers and the artists pursued divergent paths of development more or less in conflict with one another and this accounted for at least some of the architectural idiosyncrasy. However, if a metalanguage *had* existed, then the synthesis of the present century could have been achieved much earlier.

behaviour homeostatic rather than divergent. Hence, the architect is responsible for building conventions and shaping the development of traditions (this comment simply elevates the idea that a building controls its inhabitants to a higher level of organization).

Evolutionary ideas in architecture

Systems, notably cities, grow and develop and, in general evolve. Clearly, this concept is contingent upon the functionalist/mutualist hypothesis (without which it is difficult to see in what sense the *system* itself *does* grow) though the dependency is often unstated. An immediate practical consequence of the evolutionary point of view is that architectural designs should have rules for evolution built into them if their growth is to be healthy rather than cancerous. In other words, a responsible architect must be concerned with evolutionary properties; he cannot merely stand back and observe evolution as something that happens to his structures. The evolutionary thesis is closely related to holism, type *c*, but it is a carefully specialized version of *c* as manifest in the work of the Japanese.

Symbolic environments in architecture

Many human activities are symbolic in character. Using visual, verbal or tactile symbols, man 'talks with' his surroundings. These consist in other men, information systems such as libraries, computers or works of art and also, of course, the structures around him.

Buildings have always been classified as works of art. The novel sub-theory is that structures may be *designed* (as well as intuited) to foster a productive and pleasurable dialogue. This way of thinking is most clearly manifest in connection with the literary art forms, notably surrealism which relies upon a variety (novelty) producing juxtaposition of releasers and supernormal stimuli (evoking inbuilt emotive responses) within a thematic matrix. At the architectural level, this type of design appears in the vegetable surrealism of some of the Art Nouveau. But it reaches maturity in Gaudi's work, especially the Parque Guell (right) which, at a symbolic level, is one of the most cybernetic structures in existence. As you explore the piece, statements are made in terms of releasers, your exploration is guided by specially contrived feedback, and variety (surprise value) is introduced at appropriate points to make you explore.

It is interesting that Gaudi's work is often *contrasted* with functionalism. Systemically it *is* functionalism pure and simple, though it is aimed at satisfying *only* the symbolic and informational needs of man.[8]

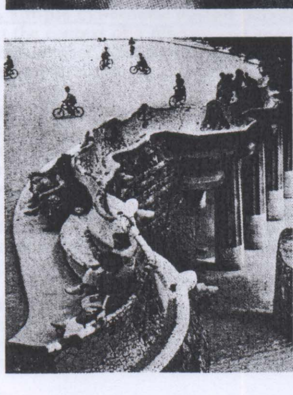
The machinery of architectural production

Just as a functionally interpreted building constitutes a system, so also the *construction* of this building is a *system*. The new techniques developed in the last century and the general mechanization of production facilities led to sub-theories concerned with the achievement of forms (the most important centred around the Bauhaus) and these, in turn, restricted the forms that could be produced.

The widening brief

As a result of these, essentially cybernetic, sub-theoretical developments, many architects *wanted* to design systems but, on the whole they were *expected* to design buildings. To a large extent this is still (quite reasonably) true. All the same, there is a sense in which the brief given to an architect has widened during the last decades.

In part this is due to a spate of problems for which no conventional solution exists (structures connected with aerospace developments, industry, research, entertainment, the use of oceans, etc.). Here, the architect is in much the same position as his Victorian predecessor when asked to build a railway station. In part, however, the restraints have been relaxed because of the greater prevalence of system orientated thinking amongst clients and public sponsors. It is, nowadays, legitimate to enter the design process much earlier, even for a conventional project. For



Guadi's Parque Guell—"one of the most cybernetic structures in existence."

Photographs: Leopoldo Pomés, Joan Prats and Joaquim Gomis.

example, it is quite commonplace to design (or at least to plan) cities as a whole with provision for their evolution. A University *need* not be conceived as a set of buildings around a courtyard with living accommodation and lecture theatre. The educational system *might*, in certain circumstances, be spatially distributed rather than localized. In any case, architects are positively encouraged to anticipate trends such as the development of educational technology and to provide for their impact upon whatever structure is erected. By token of this the architect quite often comes into the picture at the time when a higher educational system is being contemplated, without commitment to whether or not it is called a university. The Fun Palace project, by Joan Littlewood and Cedric Price, was an early entry project of this type in the field of entertainment and it is not difficult to find examples in areas ranging from exhibition design to factory building.

The point I wish to establish is that nowadays there is a *demand* for system orientated thinking whereas, in the past, there was only a more or less esoteric *desire* for it. Because of this demand, it is worth while collecting the isolated sub-theories together by forming a generalization from their common constituents. As we have already argued, the common constituents are the notions of control, communication and system. Hence the generalization is no more nor less than abstract cybernetics interpreted as an overall architectural theory.

It would be premature to suggest that the necessary interpretation and consolidation is complete. But a creditable start has been made by a number of people; citing only those with whom I have personal contact, Christopher Alexander, Nicholas Negroponte, many students and ex-students from the AA School of Architecture and from Newcastle.

Status of the new theory

In common with the pure architecture of the 1800s, cybernetics provides a metalanguage for critical discussion. But the cybernetic theory is more than an extension of 'pure' architecture. As we noted somewhat earlier, pure architecture was descriptive (a taxonomy of buildings and methods) and prescriptive (as in the preparation of plans) but it did little to predict or explain. In contrast, the cybernetic theory has an appreciable predictive power.[7] For example, urban development can be modelled as self organizing system (a formal statement of 'Evolutionary ideas in architecture') and in these terms it is possible to predict the extent to which the growth of a city will be chaotic or ordered by differentiation. Even if the necessary data for prediction is unavailable we can, at least, pose and test rational hypothesis. Much the same comments apply to predictions in which time is not of primary importance; for instance, in predicting the influence of spatial and normative constraints upon the stability of a (functionally interpreted) structure.

The cybernetic theory can also claim some explanatory power insofar as it is possible to mimic certain aspects of architectural design by artificial intelligence computer programs[8] (provided, incidentally, that the program is able to learn *about* and *from* architects and by experimenting in the language of architects, i.e. by exploring plans, material specifications, condensed versions of clients' comments, etc.). Such programs are clearly of value in their own right. They are potential aids to design; acting as intelligent extensions of the tool-like programs mentioned at the outset. Further, they offer a means for integrating the constructional system (the 'machinery of production') with the ongoing design process since it is quite easy to embody the constraints of current technology in a special part of the simulation. However, I believe these programs are of far greater importance as evidencing out theoretical knowledge of what architecture is about. Insofar as the program can be written, the cybernetic theory is explanatory.

Speculations

It seems likely that rapid advances will be made in at least five areas guided by the cybernetic theory of architecture.

1. Various computer-assisted (or even computer-directed) design procedures will be developed into useful instruments.

2. Concepts in very different disciplines (notably social anthropology, psychology, sociology, ecology and economics) will be unified with the concepts of architecture to yield an adequately broad view of such entities as 'civilization', 'city' or 'educational system'.

3. There will be a proper and systematic formulation of the sense in which architecture acts as a social control (i.e. the germ of an idea, mentioned under 'Holism', will be elaborated).

4. The high point of functionalism is the concept of a house as a 'machine for living in'. But the bias is towards a machine that acts as a tool serving the inhabitant. This notion will, I believe, be refined into the concept of an environment *with* which the inhabitant cooperates and *in* which he can externalize his mental processes, i.e. mutualism will be emphasized as compared with mere functionalism. For example, the machine for living in will relieve the inhabitant of the need to store information in memory and the need to perform calculations as well as helping out with more obvious chores like garbage disposal and washing up dishes. Further, it will elicit his interest as well as simply answering his enquiries.

5. Gaudi (intentionally or not) achieved a dialogue between his environment and its inhabitants. He did so using physically static structures (the dynamic processes depending upon the movement of people or shifts in their attention). The dialogue can be refined and extended with the aid of modern techniques which allow us to weave the same pattern in terms of a reactive environment. If, in addition, the environment is malleable and adaptive the results can be very potent indeed. I have experimented along these lines myself[9] but the work of Brodey and his group at the environmental ecology laboratory is a project on a much more impressive scale. As a broad statement of what is going on, a computer controls the visual and tactile properties of environmental materials (which are available in sufficient diversity for most architectural purposes). These materials contain sensors, tactile or visual as the case may be, which return messages to the computer at several levels of generality. In the absence of a human inhabitant, the feedback leads to stabilization with respect to certain pre-programmed invariants (for example, that a body of material shall maintain mechanical stability and occupy a prescribed value), and to a search process in which the material actively looks for signs of a human being in contact with it. If there is a human being in the environment, computer, material and all, engages him in dialogue and, within quite wide limits, is able to learn about and adapt to his behaviour pattern. There is thus one sense in which the reactive environment is a *controller* and another in which it is controlled *by* its inhabitants.

A simple cybernetic design paradigm

In the context of a reactive and adaptive environment, architectural design takes place in several interdependent stages.

i. Specification of the purpose or goal of the system (with respect to the human inhabitants). It should be emphasized that the goal *may* be and nearly always *will* be underspecified, i.e. the architect will no more know the purpose of the system than he *really* knows the purpose of a conventional house. His aim is to provide a set of constraints that allow for certain, presumably desirable, modes of evolution.

ii. Choice of the basic environmental materials.

iii. Selection of the invariants which are to be programmed into the system. Partly at this stage and partly in ii above, the architect determines what properties will be relevant in the man environment dialogue.

iv. Specification of what the environment will learn about and how it will adapt.

v. Choice of a plan for adaptation and development. In case the goal of the system is *underspecified* (as in i) the plan will chiefly consist in a number of evolutionary principles.

Of course, this paradigm applies to systems which adapt over rather short time intervals (minutes or hours). In contrast, the adaptation in a project such as the Fun Palace system took place over much longer time intervals (for instance, an 8-hourly cycle and a weekly cycle formed part of the proposal). Depending upon the time constraints and the degree of flexibility required, it is more or less convenient to use a computer (for example, the weekly cycle is more economically programmed by a flexible office procedure). But exactly the same principles are involved.

Urban planning usually extends over time periods of years or decades and, as currently conceived, the plan is quite an inflexible specification. However, the argument just presented suggests that it need not be inflexible and that urban development could, perhaps with advantage, be governed by a process like that in the dialogue of a reactive environment (physical contact with the inhabitants giving place to an awareness of their preferences and predilections; the inflexible plan to the environmental computing machine). If so, the same design paradigm applies, since in all of the cases so far considered the primary decisions are systemic in character, i.e. they amount to the delineation or the modification of a control program. This universality is typical of the cybernetic approach.

One final manoeuvre will indicate the flavour of a cybernetic theory. Let us turn the design paradigm in upon itself; let us apply it to the interaction between the designer and the system he designs, rather than the interaction between the system and the people who inhabit it. The glove fits, almost perfectly in the case when the designer uses a computer as his assistant. In other words, the relation 'controller/controlled entity' is preserved when these omnibus words are replaced either by 'designer/system being designed' or by 'systemic environment/inhabitants' or by 'urban plan/city'. But notice the trick the designer is controlling the construction of control systems and consequently design is control *of* control, i.e. the designer does much the same job as his system, *but* he operates at a higher level in the organizational hierarchy.

Further the design goal is nearly always underspecified and the 'controller' is no longer the authoritarian apparatus which this purely technical name commonly brings to mind. In contrast the controller is an odd mixture of catalyst, crutch, memory and arbiter. These, I believe, are the dispositions a designer should bring to bear upon his work (when he professionally plays the part of a controller) and these are the qualities he should embed in the systems (control systems) which he designs.[10] □

[6] Clearly, in other respects, it would be uncomfortably prickly to live in.

[7] The impact of cybernetics upon architecture is considerable just because the theory does have much more predictive power than pure architecture had. Cybernetics did relatively little to alter the shape of biochemistry for instance, because although these concepts are bound up with everything from enzyme organization to molecular biology, the discipline of biochemistry already had a *predictive* and *explanatory* theory of its own. I made the same point for engineering in an earlier footnote.

[8] I have the work of Negroponte's group (see p. 509–514) chiefly in mind, though there are other exemplars.

[9] For example, the colloquy of mobiles project and the musicolour system, *A comment, a case history and a plan in Computer Art*, Editor Jaisha Reichardt.

[10] The cybernetic notions mooted in this article, are discussed in *An approach to cybernetics*, Hutchinson, 1961 (paperback 1968) and, in a lighter vein, in "My predictions for 1984" in *Prospect*, The Schweppes Book of the New Generation, Hutchinson. London, 1962.